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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Technical Note: Sensitivity of 1-D smoke plume rise models to the inclusion of environmental wind drag" *by* S. R. Freitas et al.

Anonymous Referee #2

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The manuscript describes an extension of the parameterization of the 1D fire plume model PRM by including the effects of horizontal wind on the vertical structure of the simulated plume. The results with and without the additional terms are compared to results from the 3D plume model ATHAM. A significant improvement of the vertical structure due to the improved parameterization is shown.

General Comments

- The paper needs major revisions in terms of structure and language.

- The study is presented as a technical note. However, the text in its present form does not sufficiently explain the premises of the parameterization. The description of the

equation system, the basic assumptions and the simplifications should be improved so that the reader can understand and judge the parameterization.

- The extension of the existing parameterization is the addition of horizontal entrainment caused by lateral winds. The additional term entrainment coefficient is obtained from first principles of mass flux considerations, the entrainment is proportional to the difference of in-plume and ambient winds. Is this idea new, are there no references to existing work?

- The effects of the new parameterization are compared to ATHAM, but how does ATHAM compare to reality? Please discuss.

- The link of PRM to the Freitas parameterization used in large scale models needs to be explained.

- Simple parameterizations like the one of PRM are also used in large scale models to obtain the fire injection height that depends on subscale processes that cannot be resolved by the coarse grids of such large scale models. Therefore, the results presented in the manuscript are relevant beyond the scope of the described study, but this should be more highlighted in the paper.

Abstract

- Please explain the subject of the paper in an understandable way, i.e. also the purpose of the Freitas parameterization, possibly in the first paragraph. (Short sentences are easier to understand.)

Introduction

- P14714, L 24/25 Due to radiative cooling and the efficient heat transport by convection, there is a rapid decay of temperature above the burning area. Change to: Due to radiative cooling and the efficient dilution due to expansion during convective rise, there is a rapid decay of temperature above the burning area.

- P14715, L8: can lead to a bent-over over and enhance lateral. . .

- P14715, L 17-20: These references are quite old and only refer to (1D and 2D, discuss this short-coming) simulations of volcanic eruptions. Please add more recent literature, discuss observations of the real world (e.g. the papers of Gerald Ernst et al. in volcanic plumes) and possibly on the dynamics of fires.

Methodology

- P14716, L 0: Methodology of what? You are describing the PRM model here. Please change title.

- P14716, L 1: the rise is not explicitly simulated, but parameterized

- P14716, L 5: organized flow=advective flow?

- P14716, L 10: why is the near surface layer accelerated?

- P14716, L 12: delete additional, change size to diameter

- P14718: rewrite section:

+ explain all variables (e.g. what are B, g, in eq 1?)

+ first introduce the concept of horizontal and vertical entrainment by two variables to simplify the equations Ehor= 2/(R pi) (ue − u): horizontal entrainment (why dynamic?) Evert= 2 pi/R |w|: vertical entrainment

+ then explain the general meaning of the equations (conservation, motion, thermodyn, . . ., and how do you obtain eq 6?,)

+ finally explain the new terms and equations and explain their impacts for the inclusion of the effects of horizontal entrainment

- P14718, L 3: alpha is the entrainment coefficient? why constantly 0.05? please discuss.

- P14718, L 25: “the horizontal entrainment terms are respon. . .”

- P14719, L 3: Please give the reader a hint what a Turner style plume might be.

Case Studies, Description

- Section 3.:

+ Section 3.2, P14721, L 13-18: Move the complete description of the fire forcing to Section 3.1, as well as the McCarter&Broido factor in L15, and the environment conditions and fire size in the following lines. These have all been the same in the two models and should only be described once.

+ The model description of both ATHAM and PRM should be moved to Section 3.1, only simulation results should then be described in Section 3.2 and 3.3.

- P14719, L0: change title, e.g. to Model descriptions and conditions of the simulations, add descriptions of the fire forcing, which is now in Section 3.2., to this paragraph. The description of the simulations should be moved here from section 3.4.

- P14719, L1: give a short introduction to the following sections, and motivation of the studies. Make a table of all simulations.

- I would suggest calling the simulations windy and calm, not wet and dry, as you are discussing the effects of wind and not humidity.

- P14719, L 26: cloud microphysics is not discussed in this paper!

3.2 Case Studies, ATHAM

- The description of the simulation results is highly insufficient. Discussion needed: The atmospheric stability is lower in the wet case, so the plume should be higher, but due to lateral wind effects it is bended to the side, at the expense of vertical motion. This also happens in the case of much stronger fire forcing in the 80 ha simulation. ETC. . .

- P14720, L 8: what do you mean with external forcing? are there limitations to the solution of the Navier Stokes equations?

- P14720, L 8/9: what are active tracers? is the aerosol effect on clouds considered?

- P14720, L 20: Fluxes as in PRM, but how are fluxes in PRM? and what exactly is PRM?

- P14720, L 24: Please give a short explanation of the McCarter&Broido factor (and move to Section 3.1.). How can the conversion of heat to convective energy be constant? I guess it would be also depend on ambient conditions?

3.2 Case Studies, PRM

- P14721, Section 3.3.: The description of the simulation results is insufficient, should be comparable in detail to the ATHAM results.

- P14721, L 19: What do you mean with typically steady state is reached within the simulation time? not always, or are you not sure? In ATHAM, it is 30 min for the small fire (no information given for the large one), how long is it in PRM?

- P14721, L24: It is clear that the fire forcing for the two models are the same, but this should be written in the introduction of Section 1, before 3.1., not in this section.

3.3 Case Studies, Comparison

- P14721/22, Section 3.4:

+ Rewrite/Reorder the whole paragraph explaining VMD, separating the description of the simulation (to Section 3.1) the explanation of VMD (We parameterize the vertical mass distribution (VMD) from the vertical wind profile, see Appendix B. The purpose, the limitations... Also provide separate and sufficient descriptions of the simulation results. At the moment everything is mixed, therefore I do not comment on more details.

+ Define and explain all quantities shown in Figure 4, e.g. Ea, Ba, refer to equations.

At the moment, the explanations of the figures are obscure.

+ Ea, Ba: Add definition. How are these simulated by ATHAM? Why are there elevate values above plume top height?

+ P14722, L 5: Suddenly you are mentioning regional/global models. How does this relate to PRM? Please explain link to the Freitag parameterization in global models, in the introduction of the paper.

- P14722, L 20/26: Ea inconsistent: detrainment acceleration or deceleration?

- P14721, L 26: Please explain VDM at the beginning of the section.

4 Conclusions

- How relevant is your work: How are your results linking to fires in the real world (not to the ATHAM world), and to fire simulations in other models on different scales?

- The spatial and temporal resolutions in large scale models are much coarser than in PRM. Please add discussion of the potential effects on your parameterization of this difference.

Appendix

- P14725, L 17: change in-cloud horizontal mass flux to the turbulent horizontal mass flux within the plume

- P14726, L 9: Add a sentence explaining the purpose of Appendix B: The vertical mass distribution VDM is parameterized from the from the vertical wind profile, in order to compare the results from PRM to those from ATHAM.

- P14726, L 18: why zf > zi ? I would assume the opposite. Is the vertical velocity zero at zf, what is the threshold you use? How does it relate to the final rise of the plume (P14721m L21) which is defined by v<1m/s?

- P14726, L 20: VMD is in [%], so this should be multiplied by 100.

Figures:

- Figure 2: in the right hand side figure wet and dry cases cannot be distinguished, use solid and dashed lines. The vertical axes in all 3 figures should cover the same height and the use same axes stretching.

- Figure 3: Caption: Horizontally averaged vertical aerosol mass distribution (profile?). Please use same total height for vertical axis in all plots.

- Figure 4:

+ What do I see?? I guess it is all from PRM?? Explanations and discussions in the text insufficient.

+ The figures are too small. They should be readable in black/which prints (use different line strengths not colors)

+ Caption: Check grammar, increase understandability and readability.

+ Env. wind ON/OFF should not be written into Panel B, as it applies to all panels.

+ Legend always applys to the two panels in a row, but this should be mentions!

+ Ea, Ba???

Language and Grammar

- Change throughout the paper 'the ambient' to the ambient atmosphere,

- Exchange in-cloud with within in the plume: the focus is on fire plumes, which can be without condensed water.

- P14715, L 7: Remove blank before dot

- P14716, L 1: we describe the improvement of the 1-D parameterization. . .

- P14716, L 6: in-cloud = within the plume? if you are discussing the biomass plume, please do not use the term in-cloud, this might lead to confusion, throughout the paper.

- P14716, L 17: be consistent: either Section or Sect. throughout the paper

- P14716, L 24-26: check grammar and parentheses. Which quantity appears?

- P14718, L 1/2: "In the equations above the index e stands for the environmental value, all other variables refer to the center of mass of the plume".

- P14718, L 3: check expression: in an ambient wind

- P14718, L 6/7: mixing between in-cloud and ambient air inside the plume: cloud=plume? check language throughout the paper

- P14719: improve language and grammar, which local time is 1800Z (Z time would rather be called UTC)?

- P14721, L 6 altitude distribution -> vertical extension?

- P14721, L24: supposed -> assumed?

- P14722, L 16: broader (horizontal) -> deeper (vertical)?

- P14722, L 19: condensate water -> condensed water (and ice)?

- P14725: change Subscript env to Subscript e to be consistent with the rest of the paper, where subscript e means environment

- Description of heights are not consistent, definitions unclear:

+ P14720, L 25 outflow height -> height of neutral buoyancy?

+ P14721, L 4 emission height (=ground level) -> injection height, height of neutral buoyancy?

+ P14721, L 21: The definition of the final rise of the plume -> height of neutral buoyancy should be defined consistently in the 2 models, i.e. in ATHAM horizontally integrated vertical velocity >1m/s, how is this defined in PRM?

+ P14722, L 5: What do you mean with mass detrainment layer, vertical emission

source field? Be consistent in language, distinguish top height, injection height, umbrella region, height of neutral buoyancy. VMD gives a height interval, not one layer.

+ P14722, L 10: cloud top-> height of neutral buoyancy? (I repeat this here.)

+ P14722, L 18: detrainment zone -> height of neutral buoyancy? (repeated again.)

+ Appendix B: use other terminology: it is not the upper half part (=50% of total height) of the plume (not cloud), but the umbrella or outflow region.?

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